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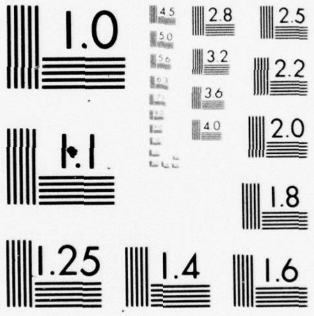

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# DEPARTMENT OF MATHEMATICAL SCIENCES

CLEMSON UNIVERSITY
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# TSA: Statistical Programs for Interactive Time Series Analysis,

by

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K. T. Wallenius

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TSA was developed by Thomas Tosch and modified by Tommy Edwards at Clemson University under the direction of Dr. K. T. Wallenius with partial support from the Office of Naval Research under contract N00014-75-C-0451.

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SECTION page

# TSA - INSTALLATION INFORMATION

The TSA program has been written entirely in IBM Fortran IV level G. Although the version in use at Clemson University was compiled with the G1 compiler, the program does not utilize any of the extensions offered by G1.

The region required by TSA is approximately 259k. This figure includes the proprietary IBM Fortran Library and Tektronix software (which are not distributed with the TSA source program).

If the program is not run on an IBM 360 or 370, it may be necessary to modify subroutine TRNSLT, the command parsing module, since it makes use of the internal representation of numbers and characters.

Distributed with the package are two routines which will be of help to installations which will be running the program under TSO. One is a command list (which should be placed in the command list library). This command list allocates all of the files necessary for TSA. The second routine is an Assembler language module which performs the same function as the command list, but is more efficient. If used, this should be assembled and placed in the system command library. The cataloged procedure for running the program in batch is also available.

Specific reference is made in the TSA manual to the Clemson Editor and Source Management System. Since this system is not yet available at other installations, the user should employ the locally available editor. The REPRO command, which is also mentioned, is part of the HASP/TSO Interface Package. If this is not available, any utility to reproduce a data set on a line printer may be used.

The program listing is liberally annotated with comments. Each subroutine is prefaced with methodology comments as well as references the the literature, where appropriate.

# SECTION I

## INTRODUCTION TO TSA

TSA (Time Series Analysis) is an interactive computer program designed to implement Box-Jenkins analysis of univariate time series which are stationary or can be made stationary with an appropriate transformation. Besides performing computations and providing plots which aid in model identification, parameter estimation, diagnostic checking, and forecasting of actual data, the program contains training modules which facilitate the developement of user understanding and intuition. Successful analysis of time series data is analogous to fingerprint identification. One has a large(infinite) file of model or theoretical fingerprints. There is a one-to-one correspondence between theoretical fingerprints and ARIMA models. Observed fingerprints (sample statistics) are "smudged" due to stochastic noise. The user, by looking at sample fingerprints, selects a "suspect" model based on his understanding of the underlying theory and the relations between sample and theoretical fingerprints. Then the processes of estimation and diagnostic checking are performed. Diagnostic checking may require additional reference to the file of theoretical fingerprints. TSA facilitates the learning of this analytic "art" by providing:

(1) A theoretical fingerprint generator: For any specified ARIMA model, the user can generate such theoretical fingerprints as the theoretical autocorrelation function, the theoretical partial autocorrelation function, the theoretical inverse autocorrelation function, the theoretical inverse partial autocorrelation function, and the forecast function (the user supplies starting values for the forecast function). While it is essential for the user to understand general properties of models (e.g. "... partial autocorrelation function ... is dominated by damped exponentials and/or damped sine waves." B/J p.73) it is quite tedious to exhibit such properties by hand for models of even moderate order. This automatic feature of TSA allows users to view a wide variety of model fingerprints, observe the effects of varying model parameters, and compare theoretical and sample fingerprints.

(2) An internal data generator: The user can generate data from any specified ARIMA model, examine its path function and sample fingerprints, proceed with model identification, estimation, diagnostic checking, forecasting, etc., so as to provide intuition training experiences.

TSA provides graphic capabilities when run from a Tektronix terminal. When run from any CRT terminal, results can be stored for subsequent hardcopy output. A batch processing feature is included for users without interactive capability.

## SECTION II

## COMMAND STRUCTURE AND FILE MANAGEMENT SYSTEM

### 2.1 CALLING SEQUENCE

After logging on and receiving the 'READY' from the computer, type the line

```
TSA IN('userid.data')
```

Required: TSA

Optional: IN('userid.data')
This automatically allocates the data file called 'userid.data' to logical unit 8, where 'userid.data' is a previously created data set as described in the section on Input.

WARNING: Calling TSA deletes data sets 'userid.tsa.bout' and 'userid.tsa.scratch'. (see section on Output)

### 2.2 COMMAND STRUCTURE

Throughout this documentation, command keywords are shown in UPPERCASE except when used in boxed-in examples where user supplied commands appear in lowercase to provide contrast from computer output. Some conventions regarding commands should be understood:

1. A command line is restricted to 72 characters.

2. At least one space must separate command keywords and numbers except when specifying a range (e.g. 4-12).

3. More than one command may appear on a single line provided the commands are separated with an '&'. For example:

```
COMM 1 & COMM 2
```

## 2.3 ENDING A TSA SESSION

To end a TSA session, type STOP .

## 2.4 FILE MANAGEMENT SYSTEM

TSA uses five internal files for handling data. It is convenient to imagine a 'pointer' which moves from file to file by either program or user control. The file on which the pointer resides at any point in time is called the 'current working file'. The five files are:

File 1: contains original, generated, transformed, or filtered data.
File 2: contains results of differencing current working file.
File 3: contains theoretical results.
File R: contains residuals after estimating parameters.
File S: current working file is saved here for subsequent retrieval when the current working file is transformed or filtered.

## 2.5 POINTER SHIFTS

Automatic: The pointer is set to File 2 when any differencing command (DIFF) is executed. It is set to File R when the estimation command (ESTM) is executed. User Controlled: To shift the pointer to Files 1, 2, or 3, the command is:

```
RES X     where X = 1, 2, or 3
```

To shift the pointer to the residuals, File R, the command is

```
RESID
```

Note: If RESID is executed while the pointer is already set on File R, the residuals will be copied into File 2 so they may be modeled. The pointer will also be set to File 2.

To restore data to File 1 from File S, the command is:

```
DATA
```

This command will result in the pointer being set to File 1 also.

# SECTION III

# INPUT

## 3.1 CREATING A DATA FILE (EXTERNAL TO TSA)

While in the 'READY' mode, invoke the Clemson Editor and proceed as shown (A complete session is shown below. Computer prompts are CAPITALIZED. Carriage return is shown as a 'C') The first line of the created file must indicate the format for each subsequent line of data.

```
+---------------------------------------------------------------------+
I                                                                     I
I  READY                                                              I
I  ce .data nonum             C                                       I
I  ED1008 - NEW MEMBER                                                I
I                             C                                       I
I  INPUT                                                              I
I  00010 (3f6.2)              C                                       I
I  00020 7.63  4.02  6.68     C                                       I
I  00030 -4.15 2.17  12.71    C                                       I
I  00040                      C                                       I
I  EDIT                                                               I
I  save                       C                                       I
I  EDIT                                                               I
I  end                        C                                       I
I  READY                                                              I
I                                                                     I
I                                                                     I
+---------------------------------------------------------------------+
```

This sequence of edit commands permanently saves the created data set called .data in the user's SMS library (the socalled Magic library). Since this type of file cannot be accessed directly, an additional step must be done during the above EDIT sequence or at a later time. To create a TSA accessible file called 'userid.data' simply insert the command

```
SAVE DATA
```

prior to issuing the END command. This saves a temporary (48 hour) copy of your data set which is TSA readable. This can also be done at a later time by invoking the Clemson Editor as follows:

```
+----------------------------------------------------------------------------+
I                                                                            I
I  READY                                                                     I
I  ce .data nonum                C                                           I
I  EDIT                                                                      I
I  save data                     C                                           I
I  EDIT                                                                      I
I  end                           C                                           I
I  READY                                                                     I
I                                                                            I
+----------------------------------------------------------------------------+
```

## 3.2 READING DATA

Reading a previously created file off disk is accomplished by naming the file in the TSA IN(userid.data) calling sequence and then executing the following READ command:

```
READ N DISK
```

where N is the number of observations (max 325) to be read. The program will prompt the user for a title. A data set can also be created at the terminal using a READ command:

```
READ N TERM
```

The first line following this command must indicate the format as in the example of 3.1, above. Data is then entered from the terminal using the specified format. The program will prompt the user for a title.

## 3.3 GENERATING DATA

In order to generate data, a model must previously have been defined and initialized (see section on Model Building). Given the initialized model, the command to generate data has the form:

```
GEN X VAR Y
```

```
Required:    GEN
Optional:    X       Number of observations (default is 150)
             VAR Y   Variance of white noise (default is 1).
                     If  included, X must be specified.
```

# SECTION IV

# OUTPUT

## 4.1 WRITING DATA TO DISK

The current data file may be output to the file 'userid.tsa.scratch' by using the command:

```
          WRITE I J K L M

     Required:    WRITE
     Optional:    I J K L M
                       are integers between 0  and 5. Inclusion results
                       in the lagged  data file being written  in addi-
                       tion to the current data file.
```

The program will prompt the user for a Fortran format for the output. Use F,G or E format codes only. An example follows.

```
+------------------------------------------------------------------+
I                                                                  I
I   COMMAND ?                                                      I
I  write 1 2                                                       I
I   ENTER OUTPUT FORMAT                                            I
I  (3f10.6)                                                        I
I                                                                  I
I                                                                  I
+------------------------------------------------------------------+
```

The results in the current working file, the lag 1, and the lag 2 of that file are output in the following format:

```
     z(1)        --        --
     z(2)       z(1)       --
     z(3)       z(2)      z(1)
       .....................
     z(t)       z(t-1)    z(t-2)
```

## 4.2 OBTAINING HARD COPY OF CRT DISPLAY

To build a file of CRT displays for subsequent hardcopy output, the command is

```
BOUT
```

This causes all CRT displays to be written to the file 'userid.tsa.bout' until such time as the user issues the command

```
TOUT
```

which terminates the background output. The BOUT and TOUT commands can be used repeatedly during a single session. Output is cumulative.

WARNING: Both output files (i.e. 'userid.tsa.bout' and 'userid.tsa.scratch') are destroyed when TSA is called. The user should rename these files if he wishes them to be saved. Hardcopy of these files can be obtained externally to TSA by using the REPRO command.

## SECTION V
## TRANSFORMATIONS

### 5.1 DIFFERENCING

The series that is differenced is the current working data file. There are two types of differences performed by the program.

#### 5.1.1 Regular

The first regular difference of a series z(t) is z(t)-z(t-1) or, in operator notation, (1-B)z(t). To perform this difference the command is

```
DIFF REG 1
```

In general, a regular difference may be of the type ((1-B)**X)z(t), where X is an integer greater than or equal to 1. The command in general is

```
DIFF REG X
```

#### 5.1.2 Seasonal

The first seasonal difference of order 12 of a series is z(t)-z(t-12) or in operator notation (1-B**12)z(t). To perform this difference the command is

```
DIFF SEAS 1 ORD 12
```

We may wish a higher difference of order 12, that is, we may wish to apply the difference ((1-B**12)**Y) where Y is an integer greater than or equal to 1. The command to be used is

```
DIFF SEAS Y ORD 12
```

If we wanted an order other than 12, the general seasonal difference is ((1-B**Z)**Y), where Z is greater than 1. Z=1 would mean that we are taking a regular difference. The general command for a seasonal difference is

```
DIFF SEAS Y ORD Z
```

The regular and seasonal differences can be combined in a single command such as

```
DIFF REG X SEAS Y ORD Z
```

The differenced data are stored in file 2 of the program and file 2 becomes the current working data file.

## 5.2 POWER, LOG, OR EXPONENTIAL TRANSFORMATIONS

### 5.2.1 Power

Here we want to perform the transformation (z(t)+Y)**X. The appropriate command is

```
TRAN X Y
```

Required: TRAN X
where X is the power to which z(t) is raised. If X is not an integer, the data must be non negative.

Optional: Y
where Y is an additive constant. If omitted, the default value is 0.

### 5.2.2 Log

The transformation performed is LOG(z(t)+Y), where log is taken base 10. Naturally, to use this transformation, all of the data must be positive. The command to use is

```
TRAN LOG Y
```

Required: TRAN LOG
Optional: Y where Y is an additive constant.
If omitted, the default value is 0.

### 5.2.3 Exponential

The transformation performed is 10**(z(t)+Y). Here extreme caution must so that the values do not exceed Fortran limits. The command to use is

```
          TRAN EXP Y
```

```
Required:      TRAN EXP
Optional:      Y      where Y is an additive constant.
                      If omitted, the default value is 0.
```

## 5.3 AUTOREGRESSIVE, POLYNOMIAL, OR SINE FILTERS

### 5.3.1 Autoregressive

The filter being used is z(t) - A1*z(t-1) - A2*z(t-2) - ... - An*z(t-n),

where n is any integer between 1 and 20, and the A's are real constants. The command to be used is

```
          FILT AR A1 A2 ... An
```

For example, to apply the filter z(t)-.5*z(t-1), the command is

```
          FILT AR .5
```

### 5.3.2 Polynomial

The filter being used is

z(t) - A0 - A1*t - A2*t**2 - ... - An*t**n,

where n is an integer between 1 and 19, and the A's are real constants. Care should be taken not to exceed Fortran limits on the data values. The command to be used is

```
          FILT POLY A0 A1 A2 ... An
```

For example, to apply the filterz(t)-4+t the command is

```
          FILT POLY 4 -1
```

### 5.3.3 Sine

The filter being used is z(t)-A1*sin(A2*t+A3), where A1, A2, and A3 are real constants. The command is

```
FILT SIN A1 A2 A3
```

There are no default values, so that A1, A2 and A3 all have to be entered.

## 5.4 CHANGING THE TIME SPAN

In some instances, the user may wish to use only a portion of the data for calculation. To set the limits on the data to be used, the following command is used.

```
TIME X-Y
```

X-Y is the interval of time over which to restrict the data (eg. 45-164). The user may again use the whole series by entering another TIME command, specifying the original limits of the time series.

## 5.5 CHANGING THE TITLE

To change the title of the data, the command is

```
TITLE
```

The next line entered should contain the new title of from 1 to 72 characters.

## SECTION VI

## BUILDING A MODEL

### 6.1 MODEL STRUCTURE

A model is defined by specifying the orders of each coefficient of the AR and MA backshift operators which are not constrained to be zero. A parameter 'type' and its 'order' are specified for each non-zero coefficient in the following format

```
MODEL T1 O1 T2 O2 ... Tn On REG X SEAS Y ORD Z
```

Required: MODEL

if no additional parameters are entered, the program will simply print out the last model specified.

Optional: T1 O1 T2 O2 ... Tn On

n is the number of parameters entered. n may be zero if no parameters are desired. T1, T2, ... Tn are the parameter types. They must be one of the following

| | |
|---|---|
| AR | regular autoregressive |
| SAR | seasonal autoregressive |
| SARA | auxiliary seasonal autoregressive |
| SARB | auxiliary seasonal autoregressive |
| MA | regular moving average |
| SMA | seasonal moving average |
| SMAA | auxiliary seasonal moving average |
| SMAB | auxiliary seasonal moving average |
| DT | deterministic trend |

These parameters must be entered in the order listed. Parameter types not desired need not be included. O1, O2, ... On are the parameter orders. These are integers greater than zero and refer to the power of the backshift operator B with which the parameter is associated. No order is to be entered for the parameter type DT. For like parameter types the orders must be in ascending order.

REG X

indicates that x regular differences are to be included in the model. It is appropriate only when a model is specified to generate data or theoretical results.

SEAS Y ORD Z

indicates that Y seasonal differences of order Z are to be included in the model. It is appropriate only when a model is specified to generate data or theoretical results.

The following examples illustrate the use of the MODEL command.

1. A stationary AR(2) model. The command is

   ```
   MODEL AR1 AR2
   ```

   Note that all of the parameters desired in the model must be entered. It is not sufficient just to specify an AR2 parameter. Also note that parameters of the same type are entered so that their orders are ascending. It would have been invalid to enter the model by MODEL AR2 AR1.

2. A stationary ARMA(2,2) model with a deterministic trend. The command is

   ```
   MODEL AR1 AR2 MA1 MA2 DT
   ```

   Note that AR parameters are entered before MA parameters and that each is entered in ascending order. DT, the parameter for the deterministic trend, is the last parameter entered and has no order.

3. A deterministic trend with 2 regular differences. The command is

   ```
   MODEL DT REG 2
   ```

   The difference goes after any parameters that are entered. No order is entered with the DT parameter. The model is non-stationary and the user will be so advised.

4. A stationary seasonal model (1,0,1)X(1,0,0) of order 6. The command is

   ```
   MODEL AR1 SAR6 MA1
   ```

   SAR represents a seasonal autoregressive parameter and the order is six. This parameter is entered after any regular autoregressive parameters but before any moving average parameters.

5. An MA(1) process with a seasonal difference of order 12. The command is

   ```
   MODEL MA1 SEAS 1 ORD 12
   ```

   Again, the difference is entered after any parameters.

## 6.2 INITIALIZATION

Before initializing model paramaters can be given, a MODEL command must have been used to define the model. To supply the initial values, the command is

```
INIT I1 I2 ... In
```

Required: INIT

Optional: I1 ... In

n is the number of model parameters which require initialization and I1 ... In are user supplied values entered in the same order as the model parameters were entered. If omitted, the program will automatically estimate initial values by solving lagged Yule-Walker equations from the autocorrelation and inverse autocorrelation functions for AR and MA parameters, respectively.

```
+----------------------------------------------------------------------+
I                                                                      I
I  COMMAND ?                                                           I
I  init .6 -.4                                                         I
I                                                                      I
I  PARAMETER INITIALIZATION                                            I
I   AR   1     0.600                                                   I
I   AR   2    -0.400                                                   I
I                                                                      I
+----------------------------------------------------------------------+
```

## 6.3 ADDING AND DELETING PARAMETERS

In order to avoid respecifying an entire model and providing initial values, single parameters can be added or deleted during the diagnostic iteration process. The command is

```
ADD T O V
```

Required: ADD T O T is the parameter type and O its order.

Optional: V

V is the initial value. If omitted, the program will compute new initial values for all parameters in the model.

To delete a single parameter, the command is

```
DEL T O
```

New initial values are computed and printed for remaining parameters.

## SECTION VII

## ESTIMATING MODEL PARAMETERS

### 7.1 LEAST-SQUARES ESTIMATES FOR THE PARAMETERS

Given a model with at least one parameter and initial values for the parameters, this option finds the least-squares estimates of the parameters based on the current working file. Having already initialized the model parameters, the command is

```
ESTM USING X-Y
```

Required: ESTM<br>
Optional: USING X-Y

If included, only z(X) through z(Y) are used in the estimation routine. If omitted, the entire current working file is used.

The program prints out the number of iterations until convergence and an estimate of S2, the variance of the white noise process. In addition, the parameter estimates, 95% confidence limits on these estimates and the correlation matrix of the estimates are printed.

The current working file is set to the residuals automatically following the estimation. Before program supplied initial estimates or least squares estimates are calculated again, the current working file should be reset.

```
+------------------------------------------------------------------------+
I                                                                        I
I                                                                        I
I   COMMAND ?                                                            I
I   estm                                                                 I
I                                                                        I
I   GENERATED  DATA                                                      I
I   MEAN =     0.0000 STD ERR =      0.0776                              I
I   200 OBSERVATIONS BEGINNING AT TIME    1                              I
I                                                                        I
I   ESTIMATION OF PARAMETERS                                             I
I   NUMBER OF ITERATIONS              2                                  I
I   SUM OF SQUARED ERRORS     165.6281                                   I
I   ESTIMATE OF S2              0.8450                                   I
I                                                                        I
I   PARAMETER     ESTIMATED VALUE     LOWER CONF VALUE     UPPER CONF VALUE
I     AR   1              0.522                0.396                0.647  I
I     AR   2             -0.435               -0.560               -0.310  I
I                                                                        I
I   CORRELATION MATRIX                                                   I
I             AR   1  AR   2                                             I
I     AR   1  1.000                                                      I
I     AR   2 -0.358   1.000                                              I
I                                                                        I
I                                                                        I
+------------------------------------------------------------------------+
```

7.2 RESIDUAL SS AT A GIVEN POINT IN THE PARAMETER SPACE

It is often desirable to investigate the behavior of the error sum of squares in the vicinity of the least squares estimates to see how sensitive the model is to small changes in parameter values. The user provides parameter values of interest through the INIT command, sets the pointer to the desired file, and the issues the command

TEST

```
+------------------------------------------------------------------------+
I                                                                        I
I  COMMAND ?                                                             I
I  test                                                                  I
I                                                                        I
I  199 RESIDUALS CALCULATED BEGINNING AT TIME    2                       I
I  SUM OF SQUARED ERRORS IS   206.3288                                   I
I  ESTIMATE OF S2 IS     1.0421                                          I
I                                                                        I
I                                                                        I
+------------------------------------------------------------------------+
```

## SECTION VIII

## DISPLAYING DATA FINGERPRINTS

### 8.1 THE DATA ITSELF

There are three methods of displaying the current working file. All three methods may be used whether the file is the original series, differenced series, residuals, etc.

### 8.1.1 Plot

To obtain a plot of the data, the command is

```
PLOT RANGE S
```

Required: PLOT

Optional: RANGE

If omitted, all the data will be plotted. If of the form X, where X is an integer, z(1) through z(X) will be plotted. If of the form X-Y, where X<Y and both are integers, z(X) through z(Y) will be plotted.

S Produces a solid (bar) plot.

### 8.1.2 List

To obtain a listing of the data, the command is

```
LIST RANGE
```

RANGE is optional and is defined above. Nine items are listed per line.

### 8.1.3 Graph

To obtain a graph of the data, the command is

```
GRPH RANGE
```

The syntax is identical to that of LIST above. This option is available only when running in the interactive mode on a Tektronix terminal.

```
+--------------------------------------------------------------------------+
I                                                                          I
I                                                                          I
I  COMMAND ?                                                               I
I  list 10-16                                                              I
I                                                                          I
I  GENERATED  DATA                                                         I
I  MEAN =    0.0000 STD ERR =    0.1307                                    I
I  200 OBSERVATIONS BEGINNING AT TIME   1                                  I
I  DATA LISTING                                                            I
I                                                                          I
I  VALUES ARE TIMES 10 ** 4                                                I
I   10- 16:  -4352   4257  10198  11271  19762  29959  33062               I
I                                                                          I
I                                                                          I
+--------------------------------------------------------------------------+
```

## 8.2 SAMPLE AUTOCORRELATION FUNCTION (SACF)

The SACF of any working file may be displayed. There is no command to calculate the SACF. Enough lags are automatically calculated prior to displaying. There are three methods of displaying the SACF and they will be described separately.

### 8.2.1 Plot

To obtain a plot of the SACF the command is

```
                    PLOT SACF RANGE E
Required:     PLOT SACF
Optional:     RANGE
```

If omitted only the lag 1 sample autocorrelation will be plotted. If of the form X, the first X lag SACF's will be plotted. If of the form X-Y, SACF's of lags X through Y, inclusive, will be plotted.

E

If omitted, the SACF will appear as solid bars. If included, the SACF will appear as X's with 2 sigma bounds appearing as U's and L's.

### 8.2.2 List

To obtain a listing of the SACF the command is

LIST SACF RANGE

RANGE is defined above. Nine lags are listed per line. The standard errors of the SACF are listed also.

### 8.2.3 Graph

To obtain a graph of the SACF the command is

GRPH SACF RANGE

RANGE is defined above. Plus and minus 2 standard errors of the SACF are automatically graphed also. This option is available only when running in the interactive mode on a Tektronix terminal.

```
+----------------------------------------------------------------------+
I                                                                      I
I   COMMAND ?                                                          I
I   plot sacf 6 e                                                      I
I                                                                      I
I   GENERATED  DATA                                                    I
I   MEAN =    0.0000 STD ERR =    0.1307                               I
I   200 OBSERVATIONS BEGINNING AT TIME   1                             I
I   SAMPLE AUTO-CORRELATION FUNCTION                                   I
I                                                                      I
I     -1.000    -0.600    -0.200     0.200     0.600     1.000         I
I       I.........I.........I.........I.........I.........I            I
I     1 :                    L   I   U                X         0.824  I
I     2 :                   L    I    U            X            0.707  I
I     3 :                  L     I     U         X              0.630  I
I     4 :                 L      I      U      X                0.554  I
I     5 :                L       I       U   X                  0.491  I
I     6 :                L       I       U X                    0.403  I
I   PLOT COMPLETED                                                     I
I                                                                      I
+----------------------------------------------------------------------+
```

## 8.3 SAMPLE PARTIAL AUTOCORRELATION FUNCTION (SPAC)

The SPAC of any working file may be displayed. There is no command to calculated the SPAC. Enough lags are automatically calculated prior to displaying. There are three methods of displaying the SPAC and they will be described separately.

### 8.3.1 Plot

To obtain a plot of the SPAC the command is

```
                    PLOT SPAC RANGE
Required:    PLOT SPAC
Optional:    RANGE
```

If omitted, only the lag 1 sample partial autocorrelation will be plotted. If of the form X, the first X lag SPAC's will be plotted. If of the form X-Y, SPAC's of lags X through Y, inclusive, will be plotted.

### 8.3.2 List

To obtain a listing of the SPAC the command is

```
             LIST SPAC RANGE
```

RANGE is defined above. Nine lags are listed per line.

### 8.3.3 Graph

To obtain a graph of the SPAC the command is

```
                    GRPH SPAC RANGE
```

RANGE is defined above. This option is available only when running in the interactive mode on a Tektronix terminal.

```
+-----------------------------------------------------------------------+
I                                                                       I
I  COMMAND ?                                                            I
I  list spac 7                                                          I
I                                                                       I
I  GENERATED  DATA                                                      I
I  MEAN =    0.0000 STD ERR =    0.1307                                 I
I  200 OBSERVATIONS BEGINNING AT TIME   1                               I
I  SAMPLE PARTIAL AUTO-CORR FUNCTION                                    I
I                                                                       I
I    1-  7: 0.824  0.088  0.082 -0.004  0.016 -0.100  0.062             I
I                                                                       I
I                                                                       I
+-----------------------------------------------------------------------+
```

## 8.4 SAMPLE INVERSE AUTOCORRELATION FUNCTION (SIAC)

The SIAC of any working file may be displayed. There is no command to calculated the SIAC. Enough lags are automatically calculated prior to displaying. There are three methods of displaying the SIAC and they will be described separately.

### 8.4.1 Plot

To obtain a plot of the SIAC the command is

```
          PLOT SIAC RANGE
```

Required: PLOT SIAC

Optional: RANGE

If omitted, only the lag 1 sample inverse autocorrelation will be plotted. If of the form X, the first X lag SIAC's will be plotted. If of the form X-Y, SIAC's of lags X through Y, inclusive, will be plotted.

### 8.4.2 List

To obtain a listing of the SIAC the command is

```
     LIST SIAC RANGE
```

RANGE is defined above. Nine lags are listed per line.

### 8.4.3 Graph

To obtain a graph of the SIAC the command is

```
          GRPH SIAC RANGE
```

RANGE is defined above. This option is available only when running in the interactive mode on a Tektronix terminal.

```
+-----------------------------------------------------------------------+
I                                                                       I
I  COMMAND ?                                                            I
I  plot siac 7                                                          I
I                                                                       I
I   GENERATED  DATA                                                     I
I   MEAN =    0.0020 STD ERR =    0.3361                                I
I    80 OBSERVATIONS BEGINNING AT TIME   1                              I
I   SAMPLE INVERSE AUTO-CORR FUNCTION                                   I
I                                                                       I
I                                                                       I
I     -1.000    -0.600    -0.200     0.200     0.600     1.000          I
I       I.........I.........I.........I.........I.........I             I
I     1 :              XXXXXXXXXXI                              -0.399  I
I     2 :                        IX                              0.030  I
I     3 :                        IX                              0.040  I
I     4 :                       XI                              -0.021  I
I     5 :                        IXXX                            0.113  I
I     6 :                  XXXXXXI                              -0.225  I
I     7 :                        I                               0.002  I
I   PLOT COMPLETED                                                      I
I                                                                       I
I                                                                       I
+-----------------------------------------------------------------------+
```

### 8.5 SAMPLE INVERSE PARTIAL AUTOCORRELATION FUNCTION (SIPA)

The SIPA of any working file may be displayed. There are three methods of displaying the SIPA and they will be described separately.

#### 8.5.1 Plot

To obtain a plot of the SIPA the command is

```
                    PLOT SIPA RANGE
Required:     PLOT SIPA
Optional:     RANGE
```

If omitted, only the sample inverse partial autocorrelation will be plotted. If of the form X, the first X lag SIPA's will be plotted. If of the form X-Y, SIPA's of lags X through Y, inclusive, will be plotted.

### 8.5.2 List

To obtain a listing of the SIPA the command is

```
LIST SIPA RANGE
```

RANGE is defined above. Nine lags are listed per line.

### 8.5.3 Graph

To obtain a graph of the SIPA the command is

```
GRPH SIPA RANGE
```

RANGE is defined above. This option is available only when running in the interactive mode on a Tektronix terminal.

```
+-----------------------------------------------------------------------+
I                                                                       I
I                                                                       I
I  COMMAND ?                                                            I
I  plot siac 7                                                          I
I   GENERATED  DATA                                                     I
I   MEAN =    0.0020 STD ERR =    0.3361                                I
I    80 OBSERVATIONS BEGINNING AT TIME    1                             I
I   SAMPLE INVERSE PARTIAL AUTO-CORR FUNCTION                           I
I                                                                       I
I                                                                       I
I     -1.000    -0.600    -0.200     0.200     0.600     1.000          I
I       I.........I.........I.........I.........I.........I             I
I     1 :              XXXXXXXXXXI                              -0.399  I
I     2 :                    XXXXI                              -0.154  I
I     3 :                        I                              -0.009  I
I     4 :                        I                              -0.002  I
I     5 :                        IXXX                            0.132  I
I     6 :                    XXXXI                              -0.155  I
I     7 :                   XXXXXI                              -0.186  I
I   PLOT COMPLETED                                                      I
I                                                                       I
I                                                                       I
+-----------------------------------------------------------------------+
```

## 8.6 SAMPLE SPECTRAL DENSITY FUNCTION (SSD)

The SSD function is displayed for the curent working file. The SSD function is calculated automatically for the frequencies requested. To obtain a plot of the SSD function the command is

```
SSD X-Y BY Z LAG K
```

Required: X-Y specifies that the SSD is to be plotted for the frequencies between X and Y. This must be a subset of (0,.5).

Z is the increment to space the frequencies.

K is the number of lags of the SACF to be used in the calculation. K lags of the SACF are calculated automatically.

One frequency is plotted per line with a heading at the top.

```
+----------------------------------------------------------------------+
I                                                                      I
I                                                                      I
I  COMMAND ?                                                           I
I  ssd 0-.2 by .04 lag 36                                              I
I                                                                      I
I   GENERATED  DATA                                                    I
I   MEAN =    0.0000 STD ERR =    0.1307                               I
I   200 OBSERVATIONS BEGINNING AT TIME    1                            I
I   SAMPLE SPECTRAL DENSITY FUNCTION                                   I
I                                                                      I
I                                                                      I
I      0.0      1.740     3.480     5.220     6.959     8.699          I
I   FREQI.........I.........I.........I.........I.........I            I
I   .0  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX      8.699 I
I   .040IXXXXXXXXXXXXXXXXXXXXXXXXX                               4.418 I
I   .080IXX                                                      0.514 I
I   .120IXX                                                      0.473 I
I   .160IX                                                       0.309 I
I   .200IX                                                       0.226 I
I                                                                      I
I                                                                      I
I                                                                      I
+----------------------------------------------------------------------+
```

## 8.7 SCATTER DIAGRAM

It is possible to obtain a scatter diagram of z(t) versus any of its lag values. To obtain a scatter diagram of z(t) vs. z(t-1) the command is

```
SCAT 1
```

In general, a scatter diagram of z(t) vs. z(t-N), where N is an integer between 1 and the length of the series, may be obtained by the command

```
SCAT N
```

```
+----------------------------------------------------------------------+
I                                                                      I
I                                                                      I
I  COMMAND ?                                                           I
I  scat 1                                                              I
I                                                                      I
I                                                                      I
I                 LAG  1 SCATTER DIAGRAM                               I
I       5.478 -                                           1            I
I             .                                       1                I
I             .                                   2    1               I
I             .                                1      1    1    1      I
I       3.504 -                           1      1 1  1   1            I
I             .                          1    11 1   1                 I
I             .                       111 2   211   11  1  1           I
I             .                1   1  1  12 1 12 11                    I
I       1.530 -           1            114 11   1                      I
I             .               1   2111131   13      1                  I
I             .                121331 111   2 1                        I
I             .             12212 323 21       3                       I
I      -0.445 -         1 11 2131212121  1 1 1 1                       I
I             .          1123  52111 12 1                              I
I             .      1 1 13441   4        1                            I
I             .1 1 11   2 1111121 1                                    I
I      -2.419 -        1111                                            I
I             .       11   1                                           I
I             .             1                                          I
I             .11                                                      I
I             I.........I.........I.........I.........I.........I      I
I           -4.393    -2.419    -0.445     1.530     3.504     5.478   I
I                                                                      I
I                                                                      I
+----------------------------------------------------------------------+
```

8.8 HISTOGRAM

With this option, a histogram of the current working file may be obtained. The command is

```
HIST N
```

Required: HIST

Optional: N indicates into how many intervals you want the range of the data to be divided. It is optional. If included, it should be between 1 and 15 inclusive. If omitted, the default value is 2*r/s where r is the range of the data and s is the sample standard deviation.

```
+----------------------------------------------------------------------+
I                                                                      I
I                                                                      I
I  COMMAND ?                                                           I
I  hist 15                                                             I
I                                                                      I
I   GENERATED  DATA                                                    I
I   MEAN =     0.0000 STD ERR =     0.1307                             I
I   200 OBSERVATIONS BEGINNING AT TIME     1                           I
I   HISTOGRAM                                                          I
I   MINIMUM =    -4.39  MAXIMUM =      5.48                            I
I                                                                      I
I   I**                                                                I
I   I******                                                            I
I   I***********************                                           I
I   I*************************                                         I
I   I********************************                                  I
I   I************************                                          I
I   I************************                                          I
I   I*****************                                                 I
I   I******************                                                I
I   I***********                                                       I
I   I******                                                            I
I   I****                                                              I
I   I****                                                              I
I   I                                                                  I
I   I*                                                                 I
I                                                                      I
I                                                                      I
+----------------------------------------------------------------------+
```

## 8.9 NORMAL PROBABILITY PLOT

With this option, a normal probability plot of the current working file may be obtained. This is especially helpful when the file contains the residuals, so that we may judge if a normal distribution assumption is reasonable. The command is

```
NORM
```

If the data are normally distributed, the plotted points should lie on or near the horizontal line of '+'s. Much deviation, especially patterned deviation, away from the line should be considered evidence that the data did not come from a normal distribution.

```
+------------------------------------------------------------------------+
I                                                                        I
I                                                                        I
I COMMAND ?                                                              I
I norm                                                                   I
I                                                                        I
I  GENERATED  DATA  --  RESIDUALS                                        I
I  MEAN =    0.0120 STD ERR =     0.0730                                 I
I  199 OBSERVATIONS BEGINNING AT TIME   2                                I
I  NORMAL PROBABILITY PLOT                                               I
I                                                                        I
I                                                                        I
I                                                                        I
I                                                                        I
I                                                                        I
I                                                                        I
I       ++++++++++++1+122134343495587X9XXXXX9953611115+2++1++++++++++++  I
I                                                   1     1              I
I                                                                        I
I                                                                        I
I                                                                        I
I                                                                        I
I                                                                        I
I                                                                        I
I                                                                        I
+------------------------------------------------------------------------+
```

## 8.10 STATISTICS IN TESTING FOR WHITE NOISE

These statistics are calculated on the current working file. They are most useful when the file contains the residuals. The command to request these statistics is

```
STAT
```

The first statistic is a test on the structure of the sample autocorrelation function of the data. The higher the value, the more structure present in the SACF. If the data are white noise, then this value comes from a Chi-Square distribution with the indicated degrees of freedom. A one-tailed test should be employed.

The number of outliers, the data values greater than 2.5 standard deviations away from zero, is printed next.

The next statistic is a runs test and is a measure of the independence of the data. If the data represent independent observations, the standardized number of runs is approximately normally distributed. A two-tailed test should be used.

Finally, the data are divided into three parts and the sample variance is calculated for each part. These values should be roughly the same and represent a measure of homoscedasticity.

```
+---------------------------------------------------------------------+
I                                                                     I
I                                                                     I
I  COMMAND ?                                                          I
I  stat                                                               I
I                                                                     I
I   STATISTICS IN TESTING FOR WHITE NOISE                             I
I                                                                     I
I   CHI-SQUARE TEST : VALUE =     28.28                               I
I                   DEG FREEDOM =    24                               I
I   NUMBER OF OUTLIERS =   2                                          I
I   NUMBER OF RUNS =  97 STANDARDIZED # = -0.489                      I
I   VARIANCE OF FIRST THIRD =        1.13634                          I
I   VARIANCE OF MIDDLE THIRD =       1.17570                          I
I   VARIANCE OF LAST THIRD =         0.88357                          I
I                                                                     I
I                                                                     I
I                                                                     I
+---------------------------------------------------------------------+
```

# SECTION IX

# FORECASTING

Before the forecast function can be displayed, the least squares estimates of the model parameters must be obtained. For instructions on doing this, see the section on Building a Model. The 95% confidence limits on the forecast and the actual values, if known, are automatically displayed along with the forecast itself. The statistics given in the heading of the display are those of the forecast function. There are three methods of displaying the forecast function. The methods will be explained separately.

## 9.1 PLOT

To obtain a plot of the forecast function the command is

```
PLOT FCST X Y
```

Required: X is the number of periods to forecast.

Y is the time at which the forecasts are to follow, that is, Y+1 is the time of the first forecasted value. Y should be greater than or equal to p+q, where p is the maximum order of the autoregressive operator and q is the maximum order of the moving average operator. Y should be less than or equal to the time of the last observation of the series.

One period is printed per line with a heading at the top. In addition to the forecast function, starting values are also plotted.

## 9.2 LIST

To obtain a listing of the forecast function the command is

```
LIST FCST X Y
```

X and Y are defined above. One period is listed per line.

## 9.3 GRAPH

To obtain a graph of the forecast function the command is

```
GRPH FCST X Y
```

X and Y are defined above. This option is available only when running in the interactive mode on a Tektronix terminal.

```
+--------------------------------------------------------------------------+
I                                                                          I
I                                                                          I
I  COMMAND ?                                                               I
I  list fcst 7 196                                                         I
I                                                                          I
I  GENERATED  DATA                                                         I
I  MEAN =   -0.0375 STD ERR =    0.0849                                    I
I    7 OBSERVATIONS BEGINNING AT TIME 197                                  I
I  FORECAST FUNCTION                                                       I
I                                                                          I
I  TIME   LOWER CONF LIM   UPPER CONF LIM   FORECAST    ACTUAL VALUE       I
I  197:         -1.498          2.105          0.303          0.596        I
I  198:         -2.445          1.619         -0.413         -0.194        I
I  199:         -2.401          1.706         -0.347         -0.286        I
I  200:         -2.130          2.127         -0.002         -0.579        I
I  201:         -1.985          2.286          0.150                       I
I  202:         -2.062          2.220          0.079                       I
I  203:         -2.171          2.123         -0.024                       I
I                                                                          I
I                                                                         I
+--------------------------------------------------------------------------+
```

# SECTION X

# THEORETICAL RESULTS

## 10.1 THEORETICAL AUTOCORRELATION FUNCTION (TACF)

To display the TACF, a model must first be entered and initialized. For instructions on doing this, see the section on Building a Model. There are three methods for displaying the TACF.

### 10.1.1 Plot

To obtain a plot of the TACF the command is

```
                    PLOT TACF RANGE
Required:     PLOT TACF
Optional:     RANGE
```

If omitted, only the lag 1 theoretical autocorrelation will be plotted. If of the form X, the first X lag TACF's will be plotted. If of the form X-Y, TACF's of lags X through Y, inclusive, will be plotted.

### 10.1.2 List

To obtain a listing of the TACF the command is

```
LIST TACF RANGE
```

RANGE is defined above. Nine lags are listed per line.

### 10.1.3 Graph

To obtain a graph of the TACF the command is

```
GRPH TACF RANGE
```

A simultaneous graph of the TACF and SACF of the current working file can be obtained. The command is

```
GRPH ACF RANGE
```

RANGE is defined above. This option is available only when running in the interactive mode on a Tektronix terminal.

## 10.2 THEORETICAL PARTIAL AUTOCORRELATION FUNCTION (TPAC)

To display the TPAC, a model must first be entered and initialized. For instructions on doing this, see the section on Building a Model. The modes of display are the same a for the TACF except, of course, one uses the keyword TPAC.

## 10.3 THEORETICAL INVERSE AUTOCORRELATION FUNCTION (TIAC)

To display the TIAC, a model must first be entered and initialized. For instructions on doing this, see the section on Building a Model. The modes of display are the same as for the TACF except, of course, one uses the keyword TIAC.

## 10.4 THEORETICAL INVERSE PARTIAL AUTOCORRELATION FUNCTION (TIPA)

To display the TIPA, a model must first be entered and initialized. For instructions on doing this, see the section on Building a Model. The modes of display are the same as for the TACF except, of course, one uses the keyword TIPA.

Some examples follow.

```
+---------------------------------------------------------------------+
I                                                                     I
I  COMMAND ?                                                          I
I  list tacf 8                                                        I
I                                                                     I
I  THEORETICAL  MODEL                                                 I
I  THEORETICAL AUTO-CORR FUNCTION                                     I
I                                                                     I
I    1-   9: 0.429 -0.143 -0.257 -0.097  0.045  0.066  0.022 -0.013   I
I                                                                     I
I  COMMAND ?                                                          I
I  plot tpac 4                                                        I
I                                                                     I
I   THEORETICAL  MODEL                                                I
I   THEORETICAL PARTIAL AUTO-CORR FUNCTION                            I
I                                                                     I
I                                                                     I
I     -1.000    -0.600    -0.200    0.200     0.600     1.000         I
I       I.........I.........I.........I.........I.........I          I
I     1 :                        IXXXXXXXXXXX                  0.429  I
I     2 :              XXXXXXXXXXI                            -0.399  I
I     3 :                        I                             0.0    I
I     4 :                        I                             0.0    I
I   PLOT COMPLETED                                                    I
I                                                                     I
I  COMMAND ?                                                          I
I  plot tiac 7                                                        I
I                                                                     I
I   GENERATED  DATA                                                   I
I   MEAN =    0.0020 STD ERR =    0.3361                              I
I    80 OBSERVATIONS BEGINNING AT TIME   1                            I
I   THEORETICAL INVERSE AUTO-CORR FUNCTION                            I
I                                                                     I
I                                                                     I
I     -1.000    -0.600    -0.200    0.200     0.600     1.000         I
I       I.........I.........I.........I.........I.........I          I
I     1 :             XXXXXXXXXXXI                            -0.423  I
I     2 :                        I                             0.0    I
I     3 :                        I                             0.0    I
I     4 :                        I                             0.0    I
I     5 :                        IXXXX                         0.169  I
I     6 :                  XXXXXXI                            -0.240  I
I     7 :                        I                             0.0    I
I   PLOT COMPLETED                                                    I
I                                                                     I
+---------------------------------------------------------------------+
```

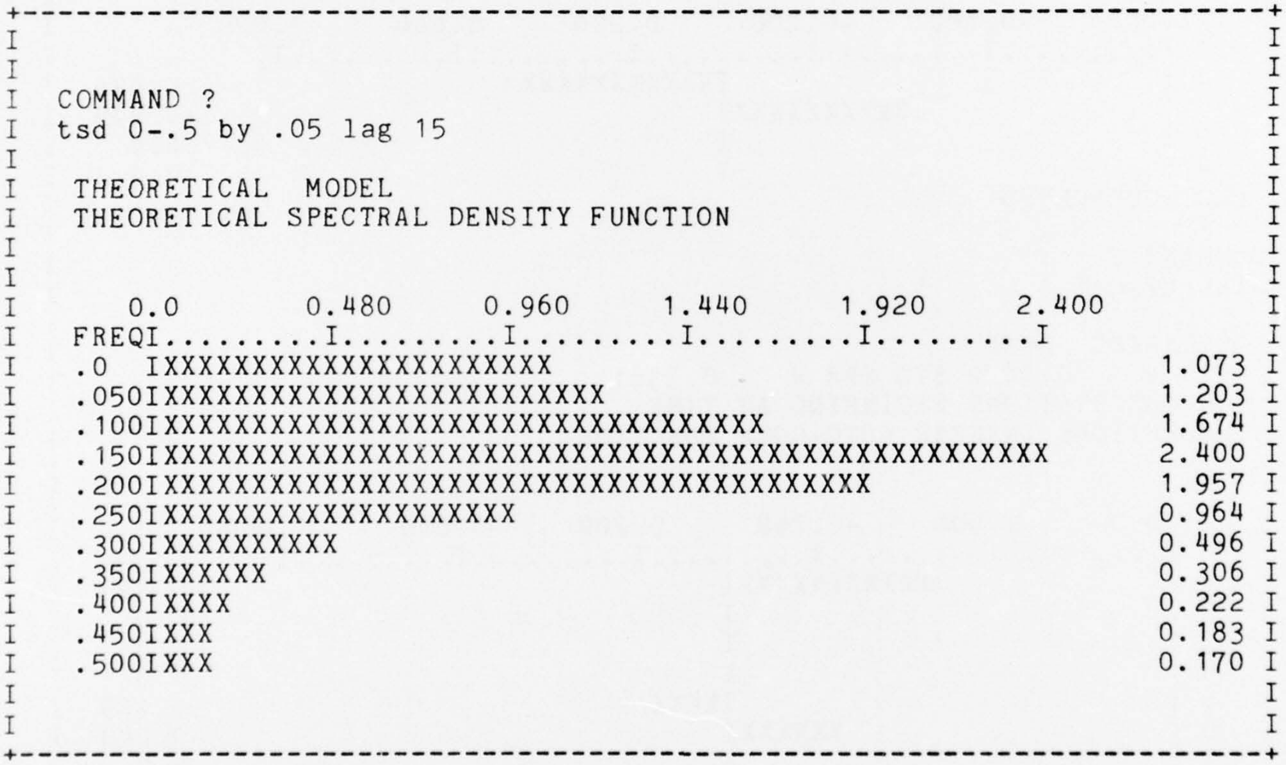
## 10.5 THEORETICAL SPECTRAL DENSITY FUNCTION (TSD)

To display the TSD, a model must first be entered and initialized. For instructions on doing this, see the section on Building a Model. To obtain a plot of the TSD the command is

```
TSD X-Y BY Z LAG K
```

Required: X-Y is the range of frequencies over which the TSD is to be plotted and should be a subset of (0.,.5).
Z is the frequency increment.
K is the number of lags of the theoretical autocorrelations to be used in the calculation.

One frequency is plotted per line with a heading at the top.



```
+-----------------------------------------------------------------------+
I                                                                       I
I                                                                       I
I  COMMAND ?                                                            I
I  tsd 0-.5 by .05 lag 15                                               I
I                                                                       I
I   THEORETICAL  MODEL                                                  I
I   THEORETICAL SPECTRAL DENSITY FUNCTION                               I
I                                                                       I
I                                                                       I
I      0.0       0.480     0.960     1.440     1.920     2.400          I
I   FREQI.........I.........I.........I.........I.........I             I
I   .0  IXXXXXXXXXXXXXXXXXXXXXX                                  1.073 I
I   .050IXXXXXXXXXXXXXXXXXXXXXXXXX                               1.203 I
I   .100IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                      1.674 I
I   .150IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX      2.400 I
I   .200IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                1.957 I
I   .250IXXXXXXXXXXXXXXXXXXXX                                    0.964 I
I   .300IXXXXXXXXXX                                              0.496 I
I   .350IXXXXXX                                                  0.306 I
I   .400IXXXX                                                    0.222 I
I   .450IXXX                                                     0.183 I
I   .500IXXX                                                     0.170 I
I                                                                       I
I                                                                       I
+-----------------------------------------------------------------------+
```

## 10.6 EVENTUAL FORECAST FUNCTION

Before the eventual forecast function can be displayed, a model with autoregressive terms must be entered and initialized. For instructions on how to do this, see the section on Building a Model. Only autoregressive terms are used in the eventual forecast. The statistics that appear in the heading of the display are those of the eventual forecast function. There are three methods of displaying this forecast function. The methods will be described separately.

### 10.6.1 Plot

To obtain a plot of the eventual forecast function the command is

```
PLOT FCST X Y S1 S2 ... Sp
```

Required: X is the number of periods to forecast.

Y must be zero. It is a code telling the program that an eventual forecast function is desired.

S1,S2,...Sp are the p starting values for the forecast values. p is the highest order of the autoregressive operator. For example, in an AR(1) process, p=1. In an AR(1) process with a first difference, p=2.

One period is plotted per line with a heading at the top. In addition to the forecast function, starting values are also plotted.

### 10.6.2 List

To obtain a listing of the eventual forecast function the command is

```
LIST FCST X Y S1 S2 ... Sp
```

X,Y,S1,S2,...Sp are defined above. One period is listed per line.

### 10.6.3 Graph

To obtain a graph of the forecast function the command is

```
GRPH FCST X Y S1 S2 ... Sp
```

X,Y,S1,S2,...Sp are defined above. This option is available only when running in the interactive mode on a Tektronix terminal.

```
+----------------------------------------------------------------------+
I                                                                      I
I                                                                      I
I  COMMAND ?                                                           I
I  plot fcst 5 0 5 10                                                  I
I   THEORETICAL  MODEL                                                 I
I   EVENTUAL FORECAST FUNCTION                                         I
I     -2.560    -0.048     2.464     4.976     7.488    10.000         I
I       I.........I.........I.........I.........I.........I            I
I     1 :               I             X                         5.000  I
I     2 :               I                                 X    10.000  I
I     3 :               I         X                             4.000  I
I     4 :   X           I                                      -1.599  I
I     5 :X              I                                      -2.559  I
I     6 :      X        I                                     -0.895  I
I     7 :           X   I                                       0.486  I
I   PLOT COMPLETED                                                     I
I                                                                      I
+----------------------------------------------------------------------+
```

## SECTION XI

## MISCELLANEOUS

### 11.1 RUNNING THE PROGRAM IN BATCH MODE

If a TSO terminal is not available, it is possible to run the TSA program in batch. A typical job setup follows.

```
+--------------------------------------------------------------------+
I                                                                    I
I   //jobname JOB (account number),'box no. and name',CLASS=F        I
I   /*ROUTE  PRINT printer-id                                        I
I   //STEP1 EXEC TSA,IN='input.data.set',OUT='output.data.set'       I
I   READ 5 CARD                                                      I
I   (5F5.2)                                                          I
I   1.01 2.02 3.03 4.04 5.05                                         I
I   THIS IS A TITLE                                                  I
I   PLOT                                                             I
I   MODEL AR 1                                                       I
I   INIT                                                             I
I   ESTM                                                             I
I   PLOT FCST 3 3                                                    I
I   STOP                                                             I
I   /*                                                               I
I   //                                                               I
I                                                                    I
I                                                                    I
+--------------------------------------------------------------------+
```

Note that the IN and OUT parameters on the EXEC card are optional. When included, they specify respectively the names of the disk data sets from which data are to be read and upon which data are to be written via the WRITE command.

## 11.2 PROGRAM MESSAGES

DIFFERENCING DONE. Given after successful completion of a difference

ESTIMATES OF MA PARAMETERS ARE NO GOOD. The procedure for calculating MA initial values diverged. User should supply the values.

FILTERING COMPLETE. Given after successful completion of a filter

FORECAST CANNOT BEGIN AT THIS STARTING POINT. The minimum starting point for a forecast is at p+q. p is the maximum order of the autoregressive operator and q is the maximum order of the moving-average operator.

INVALID COMMAND WORD . The command entered was not found, check the syntax of the command

INVALID COMMAND WORDING. Invalid syntax in a 'FILT' command.

INVALID DIFFERENCE OPERATOR. Probable cause was that a seasonal difference was specified but no order was given or the other way around. May also signal missing constants in the 'DIFF' command.

MISSING PARAMETER. No parameter included in the 'ADD' command

MODEL HAS NOT BEEN INITIALIZED. A least squares estimation is requested but the parameters do not have initial values

MODEL IS NOT INITIALIZED. The model parameters were not initialized prior to generating data

MODEL IS NOT INVERTIBLE. With either the initial values given or least squares values calculated the model is not invertible.

MODEL IS NOT STATIONARY. With either the initial values given or least squares values calculated the model is not stationary. This naturally occurs anytime a difference is entered into the model.

MODEL PARAMETERS ENTERED IN INCORRECT ORDER. See the section on entering model parameters for the proper order.

NO MODEL. An attempt was made to generate data without a model

NO MODEL TO INITIALIZE. A model must first be entered prior to initializing the parameter.

OPERATION CANNOT BE DONE BECAUSE OF NON-POSITIVE DATA VALUES. No negative data values are allowed when doing a log or power with a real exponent transformation is done.

RESIDUALS HAVE BEEN PUT INTO FILE 2. The residuals are loaded into File 2 and now can be modeled.

PARAMETER NOT FOUND. The requested parameter in the 'DEL' command was not found.

POINTER SHOULD BE SET TO 1 OR 2 TO GET INITIAL VALUES. Before the program can supply initial values or calculate least squares estimates, the current working file must be either 1 or 2.

SUM OF SQUARES CANNOT BE REDUCED FURTHER. In the estimation routine either the maximum number of iterations was exceeded or the process was not converging.

TRANSFORMATION DONE. Given upon successful completion of a transformation.

## 11.3 KEYWORDS

The following is a list of keywords used in the program. An '*' indicates that the keyword is a command word.

| | | |
|---|---|---|
| ACF | | auto correlation function |
| ADD | * | used to add a parameter to the model |
| AR | | either a regular auto-regressive parameter type or an auto-regressive filter |
| CARD | | indicates input is to be from cards |
| DATA | * | used to recall the original series |
| DEL | * | used to delete a parameter from the model |
| DIFF | * | used to perform a difference on the data |
| DISK | | indicates the input is from disk |
| DT | | parameter type deterministic trend |
| E | | indicates that standard errors of the SACF are to be plotted |
| ESTM | * | used to perform a least squares estimation |
| EXP | | indicates an exponential transformation |
| FCST | | indicates that the forecast is to be displayed |
| FILT | * | used to perform a filter on the data |
| GEN | * | used to generate data |
| GRPH | * | indicates the display is to be a graph |
| HIST | * | used to display a histogram |
| INIT | * | used to initial model parameters |
| LIST | * | the list command |
| LOG | | indicates a log transformation |
| MA | | a regular moving average parameter |
| MODEL | * | used to enter the model parameters |
| NORM | * | used to obtain a normal probability plot |
| ORD | | indicates the order of the seasonal difference |
| PLOT | * | the plot command |
| POLY | | indicates a polynomial filter |
| READ | * | used to input a series |
| REG | | indicates a regular difference |
| RES | * | command to reset the current working file |
| S | | indicates that a solid line plot is desired |
| SACF | | sample autocorrelation function |
| SAR | | seasonal auto-regressive parameter type |
| SARA | | seasonal auto-regressive parameter type |
| SARB | | seasonal auto-regressive parameter type |
| SCAT | * | used to display a scatter diagram |
| SEAS | | indicates the number of seasonal differences |
| SIAC | | sample inverse autocorrelation function |
| SIN | | indicates a sine filter |
| SIPA | | sample inverse partial autocorrelation function |
| SMA | | seasonal moving-average parameter type |
| SMAA | | seasonal moving-average parameter type |
| SMAB | | seasonal moving-average parameter type |
| SPAC | | sample partial autocorrelation function |
| SSD | * | sample spectral density function |
| STAT | * | used to get statistics on the current working file |
| STOP | * | used to terminate the program |
| TACF | | theoretical autocorrelation function |
| TERM | | indicates that input is from the terminal |

| | |
|---|---|
| TEST * | calculates the SSE for a given set of parameter values |
| TIAC | theoretical inverse autocorrelation function |
| TIME * | used to change the time span of the data |
| TIPA | theoretical inverse partial autocorrelation function. |
| TITLE* | used to change the title of the data |
| TPAC | theoretical partial autocorrelation function |
| TRAN * | perform a transformation |
| TSD * | plot the theoretical spectral density |
| USING | to use only a portion of the data in the estimation |
| VAR | used to specify the variance of the white noise |
| WRITE* | output data to the disk |

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18. SUPPLEMENTARY NOTES

Time Series
Interactive computer Program
Box-Jenkins

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

This report is a description of TSA, an interactive package of computer programs designed to implement Box-Jenkins type of analysis of univariate time series. In addition to the usual features found in many similar packages, TSA offers training modules which facilitate learning the "art" of successful time series analysis.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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